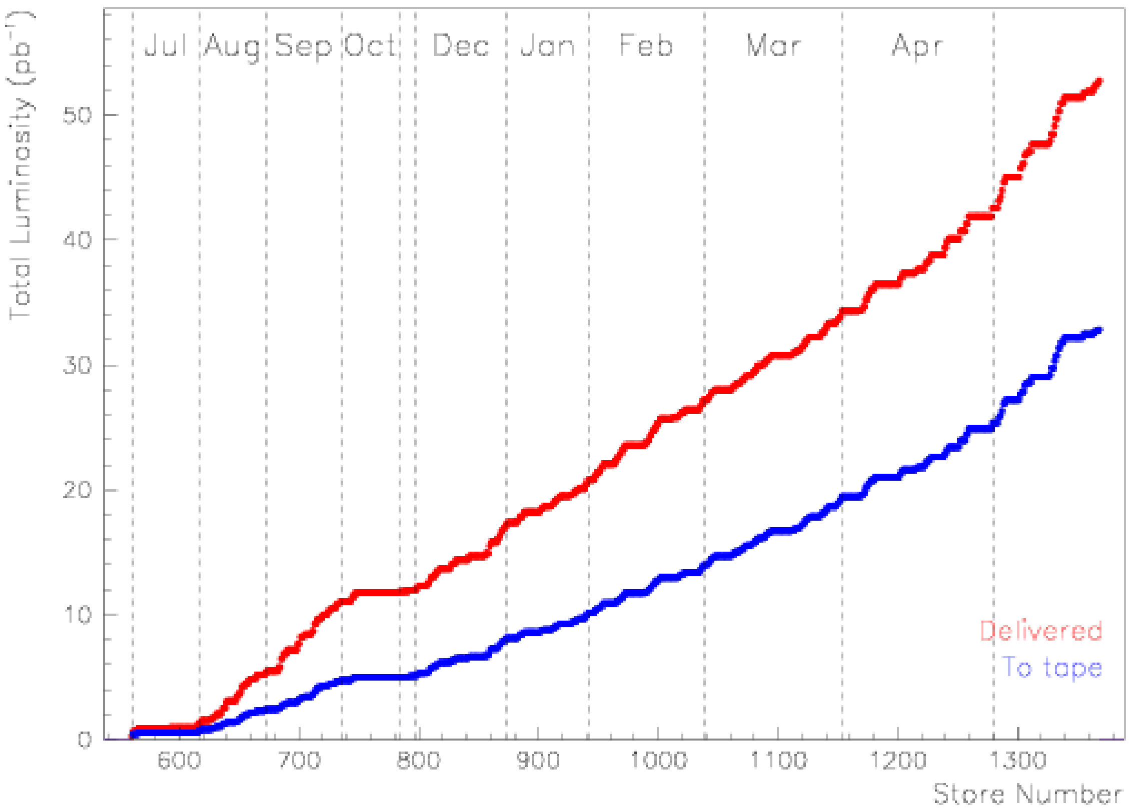
Luminosity Measurement

Delivered & Live luminosity



- L with inelastic pp
- L with W->lν
- L information
- Conclusion

- Luminosity Group
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  - M. Dittmar
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Inelastic PPbar

- Process of inelastic PPbar scattering (measured with CLC)
  - *Large x-section:* $\sigma_{inel} = 60.4 \pm 1.4\,mb$ **(CDF)**
    - → *Total x-section is measured also by E710 and E811 (2.8σ discrepancy with CDF)*
    - → *Physics groups should decide what to use*

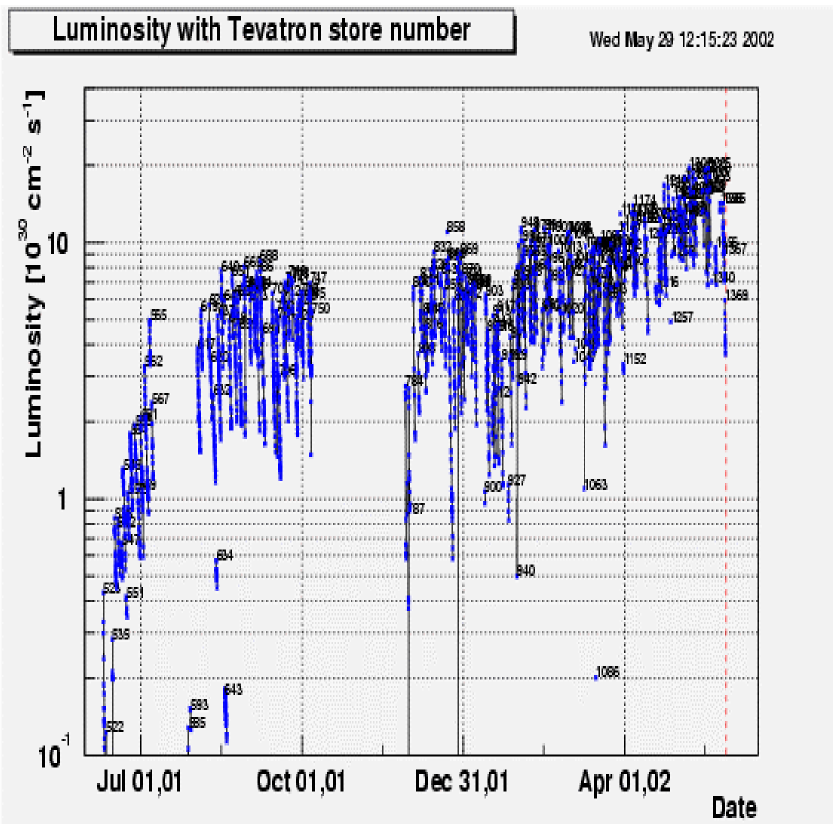
$$R_{pp} = \mu_{clc} \cdot f_{BC} = \sigma_{inel} \cdot \varepsilon_{clc} \cdot L$$

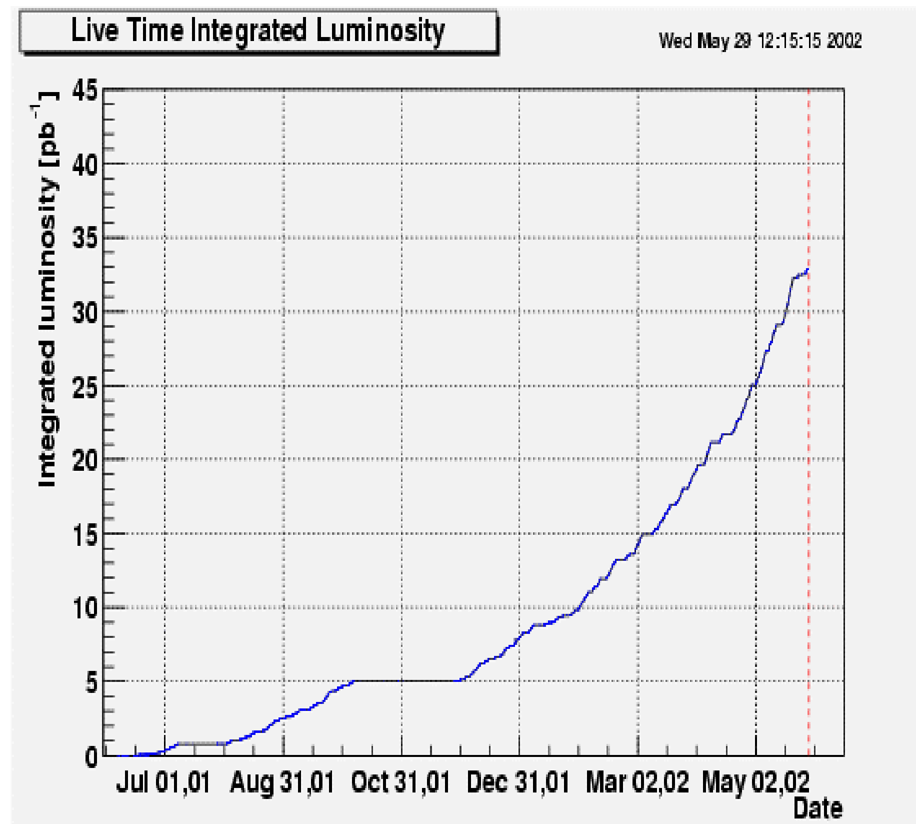
L – luminosity
f_{bc} – Bunch Crossing rate
σ_{inel} – inelastic x-section
μ_{clc} – # of pp /BC from CLC
ε_{clc} – CLC acceptance

- Measurement of μ_{clc}
  - *Counting of BC with no interactions:* $\mu_{clc} = -\ln(N_{zeroBC} / N_{totalBC})$
    - → **currently implemented for online & offline L**
  - *Counting of hits* $\mu_{clc} = \langle N_{hits/BC} \rangle / \langle N_{hits/p\bar{p}} \rangle$
  - *Counting of "particles"* $\mu_{clc} = \sum A_i / \langle A_{p\bar{p}} \rangle$
    - → **best for high L (μ>>1)**

Instantaneous & Integrated L with CLC

Peak L = $\cdot 10^{31} \, cm^{-2} s^{-1}$ Integrated L = pb^{-1}





CLC Luminosity Uncertainty

very preliminary

- Main systematic errors

Main systematic errors	expected	current
Inelastic Ppbar x-section	*2.5%*	*2.5%*
CLC acceptance	*~2%*	*<10.0%*
Detector instability	*<1%*	*2.0%*
Detector calibration	*<1%*	*1.5%*
On-line → Off-line transfer	*--*	*1.0%*
L non-linearity (high L)	*<1%*	*--*
TOTAL	*<5%*	*~10%*

ε_{clc} from CLC simulations

$$\sigma_{tot} \sim 81.9 \pm 2.3\,\text{mb} \;\nearrow\; \sigma_{inel} \sim 61.9 \pm 1.4\,\text{mb}$$

$\sigma_{inel} \to$

- $\sigma_h \sim 44.5 \pm 1.3\,\text{mb}$ hard core
- $\sigma_d \sim 10.3 \pm 0.5\,\text{mb}$ diffractive
- $\sigma_{dd} \sim 7.0 \pm 0.5\,\text{mb}$ double diffractive

} MBR

$\sigma_{tot} \searrow \sigma_{el}$ (0 acceptance)

- Acceptance: $$\varepsilon^{clc} = \frac{\varepsilon^h \cdot \sigma_h + \varepsilon^d \cdot \sigma_d + \varepsilon^{dd} \cdot \sigma_{dd}}{\sigma_{inel}}$$
- From CLC MC simulation alone (MBR):

$\boxed{\varepsilon^h = 88.6\ \%}$ **(Run I BBC ~99%, Run I D0 ~97%)** $\rightarrow \delta\varepsilon < 2.5\%$

$\varepsilon^d = 9.1\ \%$

$\varepsilon^{dd} = 31.8\ \%$

$\Rightarrow$ $\boxed{\varepsilon_{clc} \sim 68\ \% \pm ?}$

$\boxed{\sigma_{clc} = \sigma_{in} \cdot \varepsilon_{clc} \sim 42\ \text{mb}}$

Q: How accurately we know ε_α from simulation ?

ε_{clc} from CLC+plug simulation and data

- Measure CLC acceptance using a reference detector ($\varepsilon_h \rightarrow 100\%$)
  Then expect uncertainty in ε_{clc}
  $\delta\varepsilon_{clc} \sim (1- \varepsilon_h)\ldots$

$$\varepsilon_{clc} = \left(\frac{N_{clc}}{N_R} \right) \cdot \varepsilon_R$$

Measure experimentally — Find from simulation

- From simulations: CLC + PLUG (Eplug>3GeV):
  - ✓ west OR east ($\varepsilon_h \sim 100\%$,$\varepsilon_R \sim 94\%$)
- From data (west OR east): $N_{clc} / N_R \sim 67\%$ **->** affected by losses

$$\boxed{\varepsilon_{clc} \sim 63\ \%}$$

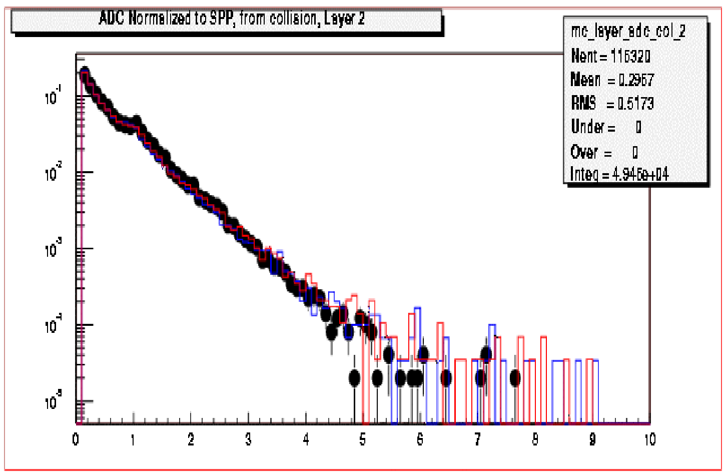
$$\boxed{\sigma_{clc} = \sigma_{in} \cdot \varepsilon_{clc} \sim 39\ \text{mb}}$$

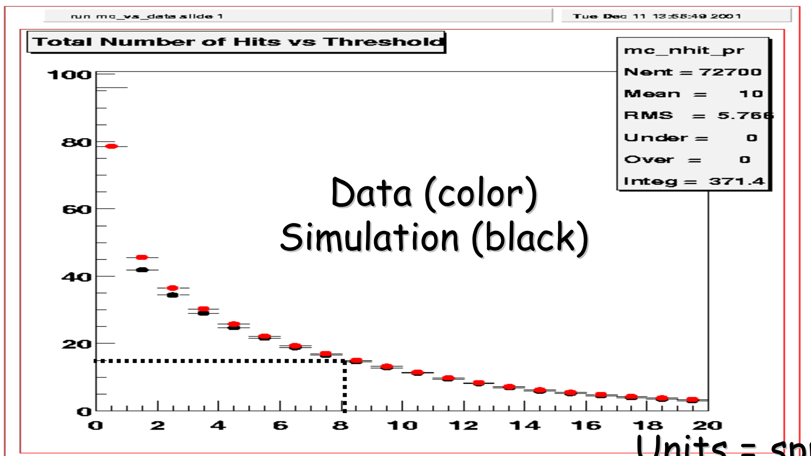
- ~8 % difference with the CLC simulation (ε_{clc}~68%) .

Summary: <10% uncertainty for now

Towards $\delta\varepsilon$<2% uncertainty

- **Simulation only** (work in progress)
  - ✓ CLC is well understood and well calibrated
  - ✓ not sensitive to the most of nasty background (soft, neutrons, …)
  - ✓ Need work to play with simulation parameters to find $\delta\varepsilon$



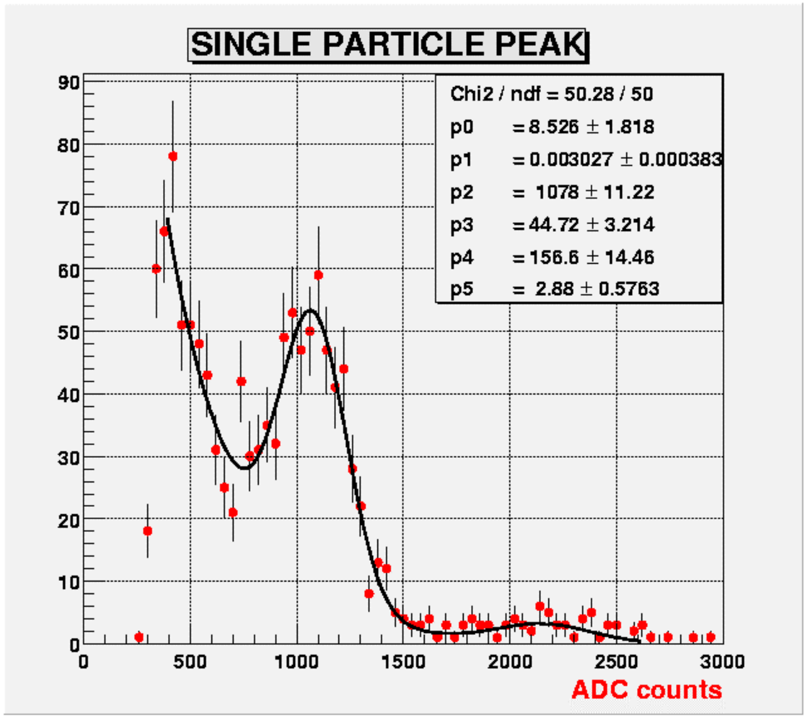


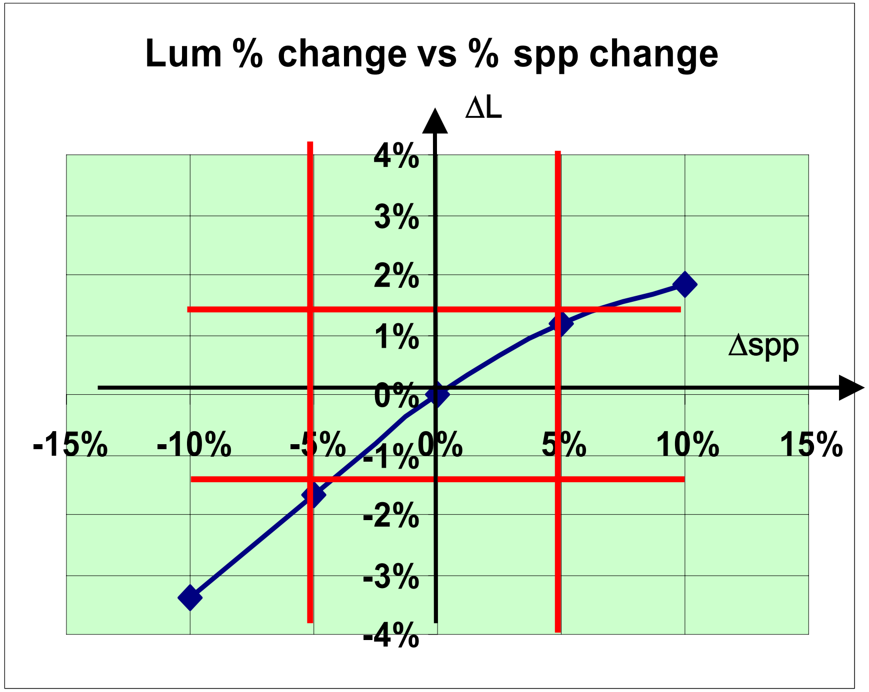
Units = spp x 10

- **CLC+Plug reference detector** (work in progress)
  - ✓ East & West coincidence → suppress losses with ToF
  - ✓ Still large acceptance: $\varepsilon^h = 97.5\,\%,\ \varepsilon^d = 20.5\,\%,\ \varepsilon^{dd} = 44.5\,\%$
  - ✓ Need understanding of plug simulation

Syst. Uncertainty due to amplitude calibration

Detector instability is corrected with the amplitude calibration





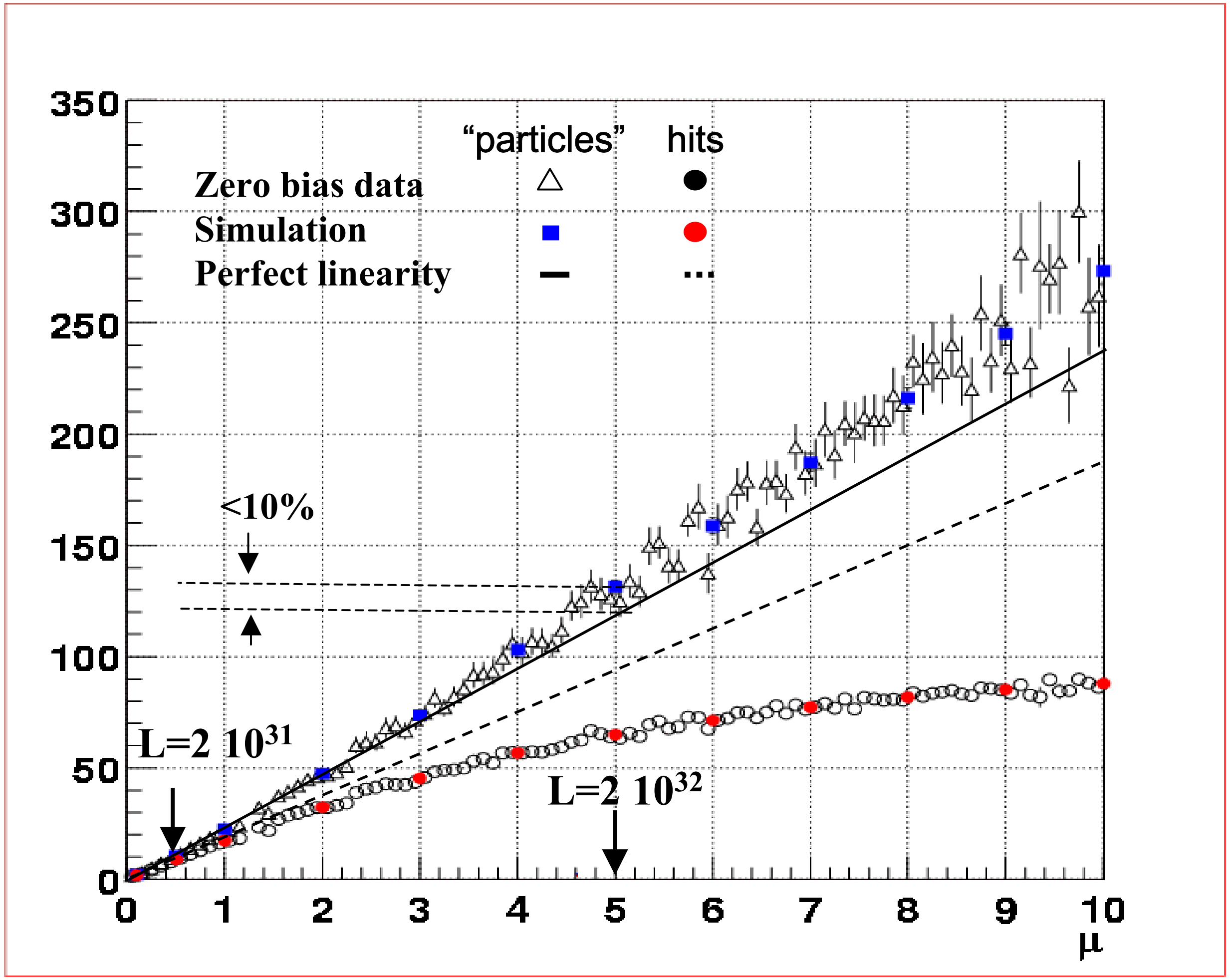
$$\Delta L / L \leq 1.5\%$$

Measuring Luminosity at High Lum

Data:
Construct bunch crossings with large μ superimposing zero bias events at low μ.

Counting of hits:
<number> of hits /BC

Counting of "particles":
Total amplitude / Ao
Ao = amplitude of single particle peak

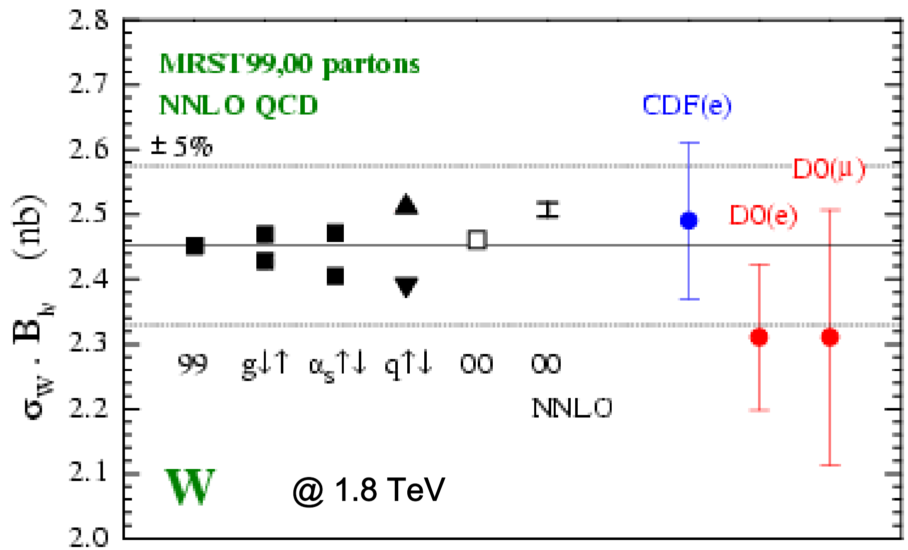


Precise high luminosity measurement is feasible !

S.Klimenko
collaboration meet 05/31/02

Luminosity with W→lep,nu

- Cross-section @ 1.96 TeV = **2.6 nb** with **~5% theoretical uncertainty** (Ellis & Stirling & Webber)
  - PDF, EWK param, scale variatic higher order corrections
- Expected rate @**L=2 10^{32} ~ 0.5Hz**
- Trigger+selection efficiency **~25%**
- Not trivial:



$$N_W = L \cdot \sigma(p\bar{p} \to WX) \cdot B(W \to e\nu) \cdot \varepsilon_{\not{E}t} \cdot \varepsilon_{E_T,\eta} \cdot \varepsilon_{Trk} \cdot \varepsilon_{P_T} \cdot \varepsilon_{Iso} \cdot \varepsilon_{ID} \cdot \varepsilon_{Event} \cdot \varepsilon_{Trig}$$

- + backgrounds …

Luminosity with W's

- *Goal:*
  - →*cross-check CLC luminosity*
  - →*Yield smaller systematic uncertainties*

- **Lum group efforts:**
  - ***Pursue "standard" analysis (W+X)***
    - ✓ ***detailed analysis of systematic errors***
  - ***Find simpler and better selection criteria***
    - ✓ ***Choice of lepton***
    - ✓ ***Simple particle ID***
    - ✓ ***Low background***
    - ✓ ***try measurement of W+0jet***

- **Working closely with the Electron Task Force**

$W \to e\nu$ + X

- Stream B high-Et electrons (bhel01)
- Filesets CA5486.* & CA65627.*
- Selection criteria:
  - *Central Et electron > 20 GeV*
  - *Track Pt > 10 GeV*
  - *Met > 20 GeV*
  - *~Standard electron ID*
  - *Pythia + full sim for geom+kin accept.*
  - *$Z \to e,e$ for electron ID + track efficiency*

- No corrections applied
- Efficiency very close to Run I
- Integrated L=5.3pb-1 (from CLC)

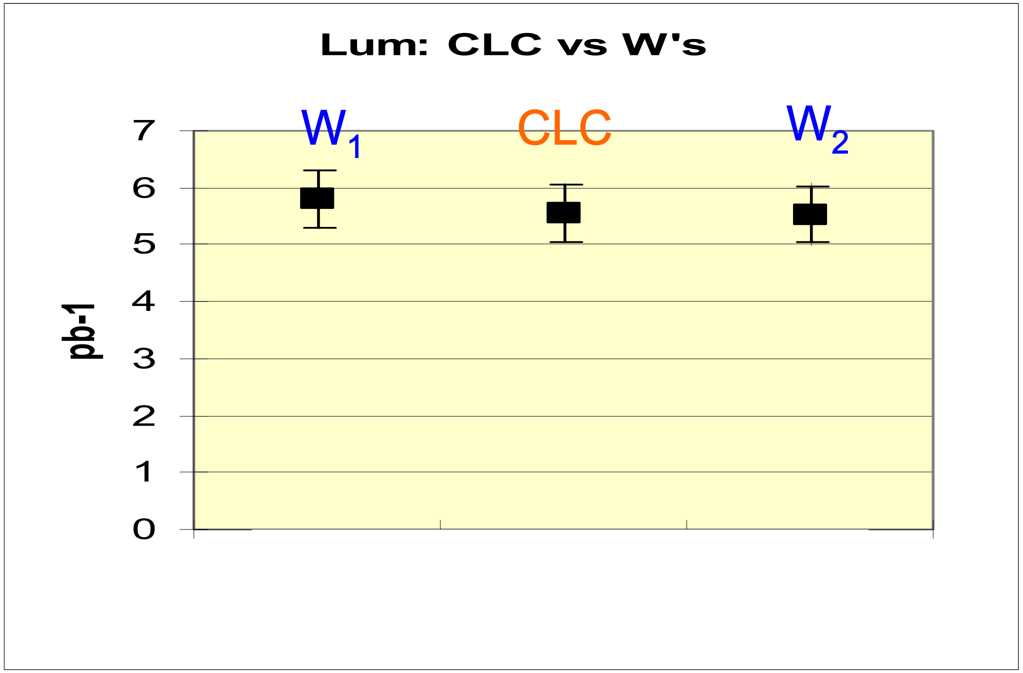
Selection	Efficiency %
Geom + Kin (MC)	32.0 (1.0)
Track finding (data)	99.2 (0.8)
Track Pt (MC)	97.8
Ele ID (data)	81.5 (2.7)
Trigger (estimate)	97 (2)
Total	24.5 (1.2)

Towards absolute normalization

$$L = \frac{N_W - N_B}{\sigma_w \varepsilon_w}$$

dL/L ~ 10%

- N_W = 3863 (after selection cuts)
- N_B = 322 (background: QCD only)
- σ_W = 2.6 nb (5%)
- ε_W = 24.5% (5%)



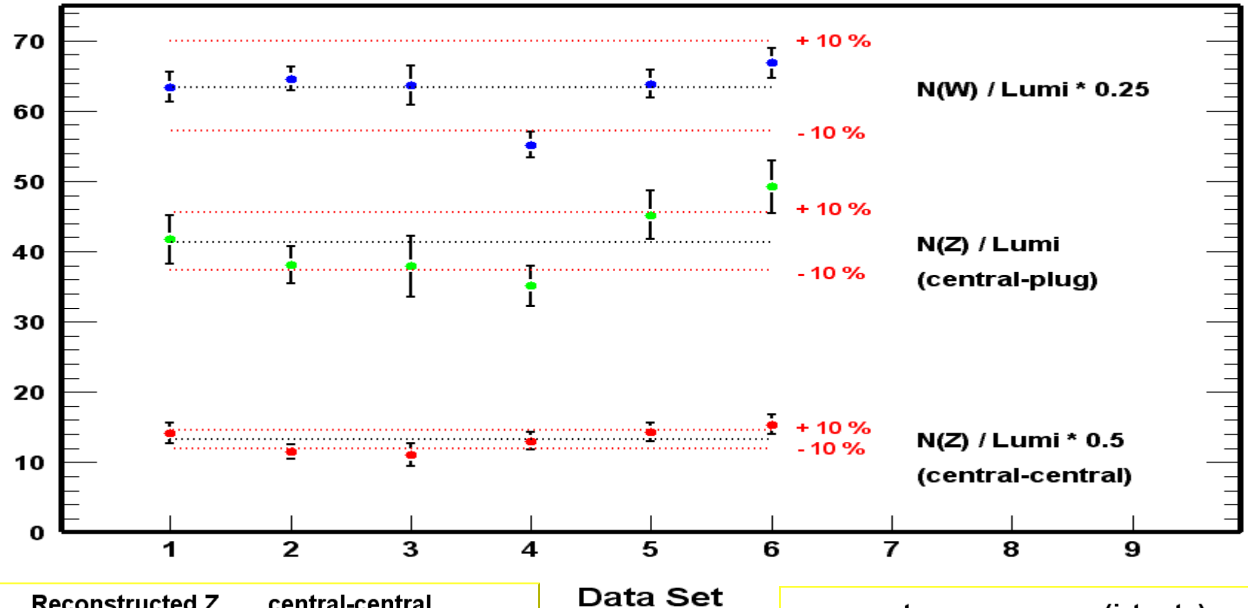
$$670\ \ Ws / pb^{-1}$$

$W_{1,2}$ = two different electron ID cuts

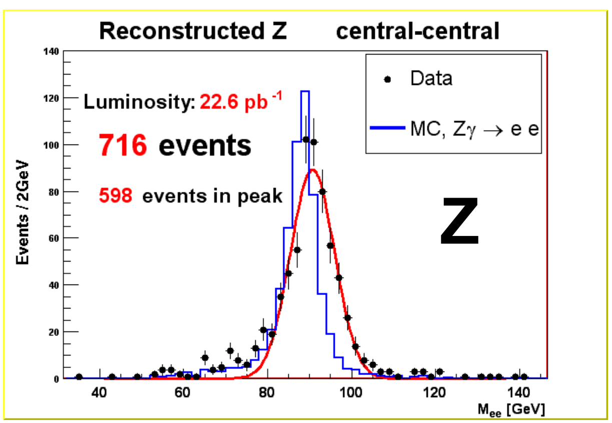
Stability of W/Z counting
(with no corrections)

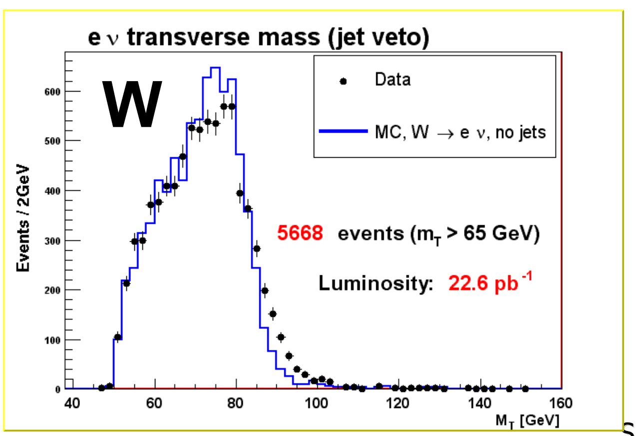
M. Dittmar
A-S Nicollerat

Nov 30 – May 19, Total L=22.6pb^{-1}
6 data segments with ~3.5pb^{-1} each



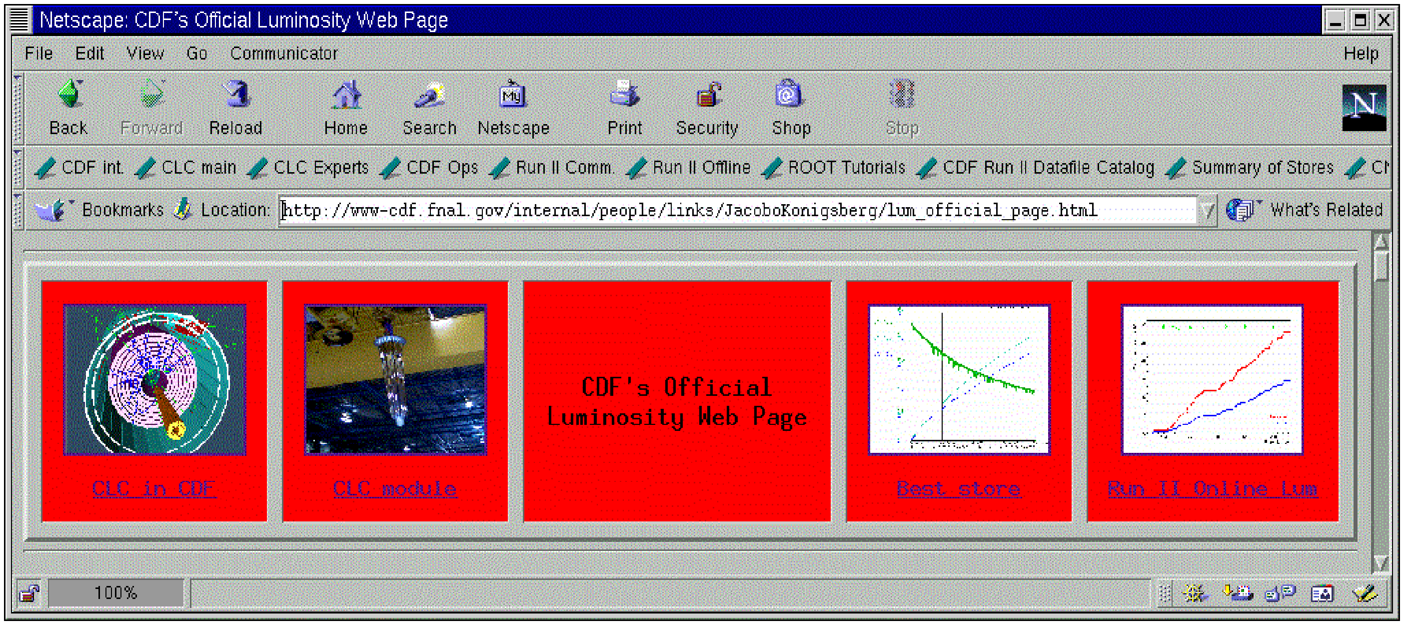
events total
5668
927
598





Official Luminosity Web Page

Access from cdf/internal→ physics in progress→ Luminosity:
http://cdfsga.fnal.gov/internal/physics/physics.html



- Instantaneous and Integrated L
- Online and Offline L
- L access for datasets
- Luminosity reconstruction and corrections
- Documentation and references

Summary and plans

- Established Lum measurements and accounting
  - ***Off-line L reconstruction coming soon***
- CLC luminosity uncertainty at the 10% level
- Working on nailing down the systematic errors
  - ***Generator, Simulation, material, thresholds, etc. etc.***
- Achieve absolute normalization uncertainty below 5%
- Implement and test high luminosity algorithms later on
- Working with W's for cross-checks
- Resolve the problem of PMTs gain instability
  - ***Strong effort in calibrations and operations***
  - ***Replace PMTs with more robust ones***

PMT gain stability